Chapter

Airway Management 3

Overview

This chapter will cover the assessment of the airway and airway management. The indications for endotracheal intubation, including pharmacologically assisted intubation, in infants and children are discussed, as well as the equipment and techniques necessary to carry out this form of airway management expediently and safely. The key to airway management is an appreciation of the need for basic life support and, if basic life support is ineffective, the need for more advanced interventions. The key to airway management via intubation is consideration of the anatomic structures of each child. Study of these considerations will help the emergency provider to act competently and confidently in the field. Appropriate drugs, with their dosages, are discussed in the section on pharmacologically assisted intubation.

Chapter Objectives

After reading this chapter, the reader should be able to:

1. Describe the airway assessment and indicated interventions.
2. Understand the importance of basic life support in the management of the pediatric airway.
3. State the indications for pediatric endotracheal intubation, the steps involved in pediatric endotracheal intubation, and why measurement with a length-based resuscitation tape and confirmation are critical steps in pediatric endotracheal intubation.
4. Understand the advantages of pharmacologically assisted intubation; the medications used and their purposes; and situations where pharmacologically assisted intubation should be used.

Case Study

You and your partner respond to the home of an unconscious two-year-old child. Upon arrival you form a first impression and immediately notice that the child, José, is not moving and there is no chest movement. You go to the child's head and open the airway with a head-tilt-chin-lift. Once you have opened the airway, you note no secretions but do hear some snoring.

→ At this point what would be your next assessment and intervention?

→ What is the significance of the snoring?

Introduction

Maintenance of a patent airway has always been the first priority of emergency care. Furthermore, in children, many problems that are not primarily airway problems can lead to compromises in airway and ventilation. Although endotracheal intubation is the gold standard for airway control, it is not always necessary. In most circumstances, proper basic life support techniques will maintain an adequate airway. But for those conditions where positioning, adjuncts, and assisted ventilation have failed, it is imperative that prehospital providers have intubation available to them and have the confidence and skill to perform this procedure.

Many EMS systems include pediatric endotracheal intubation in the advanced life support scope of practice. A few systems also advocate pharmacologically assisted intubation, a technique that uses pharmacological adjuncts to aid in intubation. Pediatric endotracheal intubation can be a challenging skill to learn and apply effectively in the prehospital setting. Furthermore, significant risks can arise from improperly performed intubation, particularly unrecognized esophageal placement. However, the lifesaving potential for critically ill or injured children frequently outweighs the risks involved.

Airway Assessment

ASSESSMENT

The goal of airway assessment is to determine airway patency and the likelihood of continued patency.

The goal of airway assessment is to determine the following:

- If the airway is patent
- Whether it is likely to remain patent
- Whether interventions are necessary to obtain and maintain patency

To determine airway patency, look for movement of the chest or abdomen, listen for breath sounds, and feel for air movement at the child's mouth or nose. If you can detect air movement and normal breath sounds, the airway is patent. In alert children, vocalization, speech, crying, or coughing indicates a patent airway, although partial obstruction may be present. If you see no chest or abdominal movement and you cannot hear or feel respiration, the airway is completely obstructed. In the unconscious patient the most likely reason is the tongue falling

back and obstructing the airway. Positioning, which should be done immediately to establish an airway and help determine patency, can treat this condition.

In pediatric patients, it is critical to perform a thorough evaluation for airway obstruction due to foreign bodies. Foreign bodies in any part of the airway can cause serious complications or death if they are not removed. Foreign body obstruction is usually manifested by a sudden onset of choking and coughing with no history of illness or injury.

- Patients with a partial upper airway obstruction from a foreign body may present with active coughing and stridor, or they may have decreased responsiveness. They are often able to maintain the airway.
- Patients with complete airway obstruction cannot cough, cry, speak, or breathe. They quickly become cyanotic and lose consciousness.

If the airway is patent, it may still be prone to become obstructed or partially obstructed. To help determine this, listen for abnormal breath sounds, which may include stridor, hoarseness, snoring, or gurgling. Stridor is usually an indication of narrowing of the upper airway and may mean that secretions, edema, or a foreign body is partially blocking the airway. Snoring often implies that the tongue is occluding the airway. Hoarseness implies either swelling or inflammation of the upper airway. Gurgling sounds may indicate the presence of secretions or blood that requires suctioning. In infants you must also inspect the nares for obstruction. Since young children are obligate nose breathers, any obstruction of the nares can significantly affect the airway.

In addition to listening, you must also inspect for potential obstruction to the airway. This includes inspecting the mouth for secretions and foreign bodies that, if not removed or suctioned, can become airway obstructions. You should also palpate the mouth, jaw, and trachea for trauma that can compromise the airway.

ASSESSMENT

Foreign body obstruction is usually manifested by a sudden onset of choking and coughing with no history of illness or injury.

ASSESSMENT

Snoring implies airway occlusion by the tongue.

Airway Interventions

Airway interventions are based on the problems identified in the assessment.

CLINICAL PEARLS

Proper positioning in itself solves many airway problems.

Airway Positioning

Proper positioning of the airway is the first intervention to perform and will often, in itself, establish a patent airway. (See the Procedure on Airway Positioning on page 72.) The most common problem is obstruction with the tongue. In the absence of suspected cervical trauma, for children who show signs of respiratory failure or arrest with apnea, unconsciousness, or inability to maintain the airway, place the patient in a supine position with a small towel under the shoulders to level the plane of the airway. In children under two years of age with a large occiput it may be necessary to pad from shoulders to pelvis to align the airway. Then open the airway using the following maneuvers:

- If trauma is evident or suspected, perform a modified jaw thrust, pushing the jaw up and slightly forward, while holding the head and cervical spine in line to prevent movement.
- If trauma is not suspected, perform a head tilt-chin lift. Tilt the head back slightly into the neutral position and lift the chin with one hand while applying gentle pressure on the forehead with the other. The trachea is more anteriorly placed in children than in adults, so less head tilt is required to open it. Hyperextending the neck can kink the airway, obstructing it.

KEY TERMS

OCCIPUT the back of the skull.

JAW THRUST pushing the jaw up and slightly forward while holding the head and cervical spine in line; the airway-opening maneuver recommended when trauma is suspected because it does not involve tilting the head back.

HEAD-TILT-CHIN-LIFT tilting the head back slightly and lifting the chin while applying gentle pressure to the forehead; the airway-opening maneuver recommended when trauma is not suspected.

Clearance of a Foreign Body

CLINICAL PEARLS

Foreign body aspiration is a dire medical emergency that will result in death if appropriate interventions are not implemented immediately.

KEY TERMS

PARTIAL AIRWAY OBSTRUCTION blockage of the airway that is not complete and that still allows the passage of some air.

COMPLETE AIRWAY OBSTRUCTION total blockage of the airway that allows no passage of air.

LARYNGOSCOPY examination of the interior of the larynx. Direct laryngyscopy is laryngoscopy performed with the aid of an instrument such as a laryngoscope.

MAGILL FORCEPS forceps (pincers) with angulated tips, used during direct laryngoscopy to remove a foreign body from the airway.

NEEDLE CRICOTHYROTOMY penetration by a needle through the cricothyroid membrane into the trachea in order to establish a route for ventilation when the airway is blocked.

Foreign body aspiration into the airway is a dire medical emergency that will result in death if appropriate interventions are not implemented immediately upon recognition. Managing an occluded airway takes precedence over all other treatments, because no other treatment will be effective if the airway is not patent. The following identifies the appropriate steps for the removal of foreign bodies in either an infant or child, and this discussion covers both manual techniques and mechanical techniques. Manual techniques include interventions that are performed by hand (for example, abdominal thrusts). Mechanical techniques utilize airway equipment as an adjunct to foreign body airway removal (for example, laryngoscopy).

A child who is actively coughing, indicating a partial airway obstruction, should be helped into a position of comfort. Offer supplemental oxygen in a manner that does not produce agitation and initiate transport. Be extremely careful not to agitate the child because this could cause the object to move into a position that completely obstructs the airway.

For a child with a complete airway obstruction, interventions must be undertaken immediately. Signs of complete airway obstruction include a child who has received assisted ventilation using a bag-valve-mask device, with adequate airway positioning, with no visible chest rise or a conscious child with signs such as cyanosis or an inability to speak, cough, or breathe. In cases such as these, perform basic airway clearing maneuvers according to the child's age. (See the Procedures on Airway Clearance—Conscious Infant, Unconscious Infant, Conscious Child, and Unconscious Child on pages 73–75.)

In infants, deliver five back blows followed by five chest thrusts. In children older than one year, deliver five abdominal thrusts only. In the unconscious patient and if the foreign body can be clearly seen in the child's mouth at any point during these maneuvers, remove it. Assess for clearance of the obstruction that will be indicated by successful assisted ventilation in the unconscious child or evidence of air movement (coughing, crying, speaking) in the conscious child. If an obstruction is still present repeat the steps.

If there is still no chest rise in the unconscious patient, perform direct laryngoscopy and attempt to locate the obstruction. Remove the foreign body using the pediatric Magill forceps only if it is clearly visible and accessible. If you cannot see and remove the object, prepare the child for transport. Continue to deliver back blows and chest thrusts or abdominal thrusts followed by assisted ventilation until ventilation is successful or patient care is transferred to hospital personnel.

Patients with persistent upper airway obstruction despite repetitive basic life support airway clearing maneuvers and attempts at laryngoscopic foreign body removal may benefit from the passage of an endotracheal tube through the vocal cords, as described later in this chapter. This procedure may push the obstruction deeper into the airway, most likely into the right mainstem bronchus, allowing ventilation of the left lung or part of the left lung. It is a stop-gap measure aimed at keeping the patient alive until the obstruction can be removed at the hospital.

Needle cricothyrotomy is used in some EMS systems when other attempts at clearing the airway fail (see the Procedure on Needle Cricothyrotomy on pages 76–77.) However, this procedure may produce complications in children, including failure to cannulate the tracheal space and possible tracheal damage due to difficulty in identifying landmarks. Almost all pediatric patients can be effectively ventilated using airway opening maneuvers and BVM ventilation. Needle cricothyrotomy may be performed if you are trained and medical direction permits, but only for long transport times when all other methods of establishing an airway have failed.

Any child with a potential foreign body aspiration must be transported for further evaluation in the emergency department. Even if the child appears to have recovered, the foreign body may remain lodged in the lower airway.

Suctioning

In addition to a partial or complete foreign body obstruction, the airway can be compromised if the airway is blocked with emesis, secretions, small particles, or blood. In these cases, first attempt to remove any foreign matter that can be clearly seen, using a finger sweep for large particles. Then attempt to gently suction any additional visible materials.

A large-bore suctioning device is frequently required, even for infants, when material found in the mouth or throat is too large for the bulb syringe. A bulb syringe may be used to remove liquids and small particles. If the patient is conscious with an active gag reflex, carefully control the tip of the device to avoid stimulating the pharynx. After suctioning, assess for signs of improvement such as spontaneous respiratory effort, pink color returning to the skin, or improved mental status. Suctioning is one of the most commonly overlooked steps in pediatric airway management. It should frequently be done earlier, before airway compromise occurs, to protect the airway and prevent aspiration of material.

Be sure to check for nasal secretions in infants. A bulb syringe or suction catheter will usually suffice for nasal suctioning.

CLINICAL PEARLS

Suctioning is one of the most commonly overlooked steps in pediatric airway management. If possible, it should be done early, before airway compromise occurs, to protect the airway and prevent aspiration.

Airway Adjuncts

For unconscious patients, an oropharyngeal airway adjunct can be used to control the airway and keep the tongue from falling back against the posterior pharynx. (See the Procedure for Oropharyngeal Airway on page 78.) Perform this procedure only after you have manually opened the patient's airway, applied suctioning, and attempted to provide assisted ventilation. Selecting a correctly sized oral airway is critical because an improperly sized airway can cause further obstruction. Measure the airway adjunct by placing the flange of the airway at the level of the child's central incisors. The distal tip of the airway should reach the angle of the jaw. Two insertion techniques can be used:

Using a tongue depressor: Hold the tongue in position with the tongue depressor and insert the oral airway with the curve downward. Slide it into position with the flange resting against the lips.

Without a tongue depressor: To use the outer curve of the oral airway as a tongue depressor, point the tip of the airway upward, but not to the point that it touches the roof of the mouth. Use the curved portion of the airway to depress the tongue and advance the airway into the mouth until the flange is near the lips, then rotate the airway 180 degrees so that the airway curves downward. Slide it into position with the flange resting against the patient's lips. We discourage use of this method in small children because their palates are soft and susceptible to damage from the airway insertion. Instead, use the tongue depressor method.

KEY TERMS

OROPHARYNGEAL AIRWAY
a curved device inserted into the mouth to displace the tongue from the back of the pharynx in order to maintain the airway.

In patients without foreign body airway obstruction but whose airway cannot be maintained with airway positioning alone, consider placing a nasopharyngeal airway adjunct to help keep the air passage between the nose and the back of the throat open for suctioning or oxygen delivery. (See the Procedure for Nasopharyngeal Airway on page 79.) You should remember that the nasopharyngeal airway is an adjunct, which means it is additive, and airway positioning should be maintained even after its insertion.

KEY TERMS

NASOPHARYNGEAL AIRWAY
a flexible tube inserted through the nose and into the pharynx just below the base of the tongue in order to maintain the airway.

Nasal airways are appropriate for conscious children who cannot maintain an open airway. They should not be used in children with facial trauma or head injuries.

It is important to select a correctly sized nasal airway. It should be about the same thickness as the patient's little finger. The correct insertion distance is from the nose to the tragus of the ear. Apply a water-soluble lubricant and slowly insert the airway into the child's nare, holding the airway at a right angle to the face. During insertion, keep the bevel toward the nasal septum and direct the airway straight back along the floor of the nasal passage. Suction as necessary to clear secretions. Maintain a head-tilt-chin-lift or jaw thrust to keep the tongue from occluding the nasopharyngeal opening in the posterior pharynx.

CHILDREN ARE DIFFERENT

The infant or child's prominent occiput makes it easy to hyperextend the neck, which can collapse a child's flexible tracheal rings.

CHILDREN ARE DIFFERENT

In younger children, the cricoid ring is narrower than in older patients, so uncuffed endotracheal tubes should be used.

KEY TERMS

CRICOID RING/CRICOID CARTILAGE The ring-shaped lowermost cartilage of the larynx.

ENDOTRACHEAL TUBE tube passed into the trachea to maintain and protect the airway.

END-TIDAL CARBON DIOXIDE DETECTOR device that can be attached to an endotracheal tube that measures the carbon dioxide concentration in exhaled air. A lack of carbon dioxide indicates probable misplacement in the esophagus.

MECONIUM The first fetal feces, a greenish substance that must be aspirated from the mouth and nose; indicates a degree of fetal distress.

Pediatric Endotracheal Intubation

For the patient whose airway cannot be maintained with positioning, suctioning, adjuncts, and attempts at assisted ventilation, it is appropriate to secure the airway with endotracheal intubation. Other patients may also require intubation earlier in the sequence of emergency care, including children with:

- Meconium aspiration during out-of-hospital delivery (see Chapter 13)
- Anaphylaxis with airway compromise
- Airway burns
- The need for a medication delivery route

Performing endotracheal intubation in children is similar to performing it in adults. Differences primarily involve changes in equipment and positioning due to the different anatomy of children and adults. (See the following discussion of differences between the adult and pediatric airway as well as the discussion and illustrations in Chapter 4.) When performing endotracheal intubation, keep the following points in mind:

- Positioning the patient on a stretcher or table with a surface slightly above your eye level makes it easier to see the child's vocal cords.
- The prominent occiput makes it easy to hyperextend the neck, which can collapse a child's flexible tracheal rings. In children, the vocal cords are higher and more anterior in location than in an adult, which also affects positioning.
- In younger children, the narrowest portion of the airway is at the level of the cricoid ring, and pressure from a cuff can damage soft tissue at this level. The cricoid cartilage itself forms a living cuff around the endotracheal tube, so younger children require an uncuffed endotracheal tube.
- A curved laryngoscope blade may not adequately control and retract a child's longer, more pliable epiglottis to permit a clear view of the glottic opening, and therefore straight (Miller) blades are preferred.
- Adjuncts to assess proper endotracheal tube placement are strongly recommended. The method of choice uses calorimetric or electronic end-tidal carbon dioxide detectors.

Equipment for Pediatric Endotracheal Intubation

The following items are needed to perform endotracheal intubation (see also the Procedure on Equipment for Pediatric Endotracheal Intubation on pages 80–83).

- Large-bore and endotracheal suction catheters, tubing, and vacuum source
- Meconium aspirator (essential for newborns when meconium is present)

- Bag-valve-mask devices in all appropriate sizes, with oxygen attachments
- Pediatric oropharyngeal airways in all appropriate sizes
- Pediatric laryngoscope handle with extra batteries
- Straight (Miller) laryngoscope blades in sizes 0 to 3 with extra bulbs
- Curved (Macintosh) laryngoscope blades in sizes 0 to 3 with extra bulbs
- Pediatric endotracheal tube stylets in small and large sizes
- Uncuffed pediatric endotracheal tubes in sizes 2.5 to 5.5 mm
- Endotracheal tubes with cuffs in sizes 6.0 to 8.0 mm
- Magill forceps in pediatric and adult sizes
- Pulse oximeter
- End-tidal carbon dioxide detection device
- Adhesive tape or other devices to secure the endotracheal tube
- Length-based resuscitation tape

These items should be stored in an easily accessible equipment bag. Become thoroughly familiar with the bag and its contents during practice sessions.

Pharmacologically Assisted and Rapid Sequence Intubation (RSI)

In some emergency situations, it is difficult or impossible to perform direct laryngoscopy and endotracheal intubation without use of adjunctive medications. Patients who typically require pharmacologically assisted intubation include:

- Head-injured patients
- Patients in status epilepticus (continuous seizures)
- Combative patients

As a result of progressively severe hypoxia and hypercarbia, the patient without a patent airway will eventually lose all muscle tone, at which point intubation may be performed successfully without pharmacologic assistance. However, once this stage is reached, irreversible brain injury and death are imminent. In such situations, pharmacologically assisted intubation using rapid sequence intubation (RSI) with or without a neurosurgical induction may be warranted.

The term pharmacologically assisted intubation encompasses all intubations that employ medication to help assist in performance of the procedure. Rapid sequence intubation (RSI) is a form of pharmacologically assisted intubation that uses pharmacological adjuncts to facilitate intubation while minimizing the chance of aspiration in a patient who has not been properly prepared for intubation. In emergency settings, this group includes patients with a full stomach. In addition, medications can be chosen for RSI to reduce the likelihood of elevated intracranial pressure during intubation. When medications that control intracranial pressure are used, the intubation is referred to as one with a neurosurgical induction.

The use of these medications is not without risk. Before attempting to perform this procedure, you must have special training as well as a thorough understanding of the pharmacological properties, indications, and contraindications of all drugs involved. Providers performing pharmacologically assisted intubation must also be highly effective at assisted ventilation in children. This skill is usually required prior to an intubation attempt and will always be required if intubation attempts prove unsuccessful after sedatives and paralytics have been administered.

KEY TERMS

STYLET a pliable wire inserted into an endotracheal tube to provide shape and stiffness.

PULSE OXIMETER electronic device attached to a finger, ear lobe, or other body part that can measure the concentration of oxygen in arterial blood.

LENGTH-BASED RESUSCITATION TAPE a marked tape that can be extended alongside an infant or child to help estimate height and weight and determine appropriate equipment sizing, insertion depths, and dosages.

HYPOXIA a deficiency of oxygen in the body cells.

HYPERCARBIA an excess of carbon dioxide in the blood.

PHARMACOLOGICALLY ASSISTED INTUBATION use of drugs to assist in endotracheal intubation.

RAPID SEQUENCE INTUBATION (RSI) use of drugs to facilitate endotracheal intubation and minimize chances of aspiration, including sedative, paralytic, and amnesic drugs.

NEUROSURGICAL INDUCTION use of drugs that control intracranial pressure.

CLINICAL PEARLS

In the presence of severe hypoxia and hypercarbia, pharmacologically assisted intubation may be warranted.

Pharmacological Adjuncts

The types of drugs administered in pharmacologically assisted intubation can include the following (Table 3-1):

- A preparatory medication, such as lidocaine, to blunt increased intracranial pressure (called a neurosurgical induction), atropine, to reduce the possibility of bradycardia and hypotension, or a medication to reduce secretions such as glycopyrrolate or atropine
- A sedative agent to provide central nervous system relaxation, which may also provide anxiolysis and amnesia
- A paralytic agent (also called a neuromuscular blocker) to relax the muscles, open the vocal cords, and keep the patient from moving

In general, pharmacologically assisted intubation may not be appropriate for certain patients, such as

- Patients whose clinical condition is severe enough to render medications unnecessary for intubation
- Patients with upper airway compromise, which also constitutes a relative contraindication to paralysis
- Patients who have anatomic features, injuries, or pathology that make successful intubation unlikely and who, upon paralysis, would completely lose their airway (e.g., those with massive swelling of the tongue, trauma to the jaw and mouth, tracheal stenosis)
- Those for whom, after providing sedation, you are unable to maintain the airway with positioning or whom you cannot ventilate adequately with a BVM device

Although some head trauma patients may not be appropriate for paralysis, they may still be appropriate for neurosurgical induction.

KEY TERMS

SEDATIVE a calming drug.

ANXIOLYSIS anxiety reduction.

AMNESIA forgetfulness about an event or procedure.

PARALYTIC a drug that induces muscle relaxation and paralysis, the inability to move.

STENOSIS constriction, narrowing.

HEMODYNAMIC regarding the circulation of the blood.

HYPOTENSION low blood pressure.

Additional Issues in Pharmacologically Assisted Intubation

Hemodynamic Effects In pharmacologically assisted intubation, the combined effects of assisted ventilation, intubation, and pharmacological adjuncts can have serious hemodynamic consequences. Hypotension must be carefully

TABLE 3-1 Drugs for Pharmacologically Assisted Intubation

Premedication	Sedation	Paralysis
Atropine	Thiopental	Succinylcholine
Glycopyrrolate	Ketamine	Rocuronium
Lidocaine	Etomidate	Vecuronium
	Fentanyl	Pancuronium
	Diazepam	
	Midazolam	
	Propofol	

monitored whenever pharmacologically assisted intubation is performed. The potential for hypotension can also be reduced by careful selection of appropriate sedative agents. Sedative drug dosage may need to be decreased in patients who are already hypotensive. Note, however, that the dose of paralytic agents should not be decreased under any circumstances; partial paralysis could lead to a catastrophic situation in which the patient cannot breathe spontaneously, but the degree of muscle tone prevents intubation or assisted ventilation.

Timing and Sequence of Drug Delivery

Avoidance of hypoxemia is a critical issue in pharmacologically assisted intubation. Drug administration lengthens the overall time required to intubate the patient, which increases the risk of dangerous hypoxemia developing during the procedure. Most ill or injured children who meet clinical criteria for intubation are already somewhat hypoxic or have increased oxygen needs.

This creates a potentially serious timing problem for pharmacologically assisted intubation: Sedatives will cause apnea when administered in proper doses, so oxygen deprivation may begin as soon as the sedative takes effect. Intubation cannot be attempted until onset of paralysis. Doubling or tripling the dose can reduce the onset time for nondepolarizing paralytic agents, but this will increase the duration of effect. Premedication with a small priming dose of the paralytic agent can also hasten the onset of paralysis; however, this advance dose can potentially cause apnea or impaired ventilation, increasing the period during which the child is oxygen deprived.

The solution may be to administer the paralytic agent before the sedative, as the paralytic agent takes longer to work. In all circumstances, however, you must ensure that paralysis does not take effect before the onset of sedation.

When Pharmacologically Assisted Intubation Fails

If pharmacologically assisted intubation is ultimately unsuccessful, bag-valve-mask ventilation will be absolutely essential to ensure oxygenation and ventilation until the paralytic and/or sedative agent wears off.

CLINICAL PEARLS

Avoidance of hypoxemia is critical in pharmacologically assisted intubation. Precise timing of drug administration and assisted ventilation is required.

KEY TERMS

HYPOXEMIA inadequate blood oxygen levels.

CRICOID PRESSURE the Sellick maneuver; pressure applied to the cricoid ring to press backward against and partially occlude the esophagus for the purpose of moving airway structures into a better position for visualization and intubation and reducing the chances of regurgitation from the stomach.

CLINICAL PEARLS

In pharmacologically assisted intubation, you must ensure that paralysis does not take effect before the onset of sedation.

CLINICAL PEARLS

If pharmacologically assisted intubation is ultimately unsuccessful, BVM ventilation will be absolutely essential to assure oxygenation and ventilation until the paralytic agent wears off.

Procedure for Pediatric Endotracheal Intubation

Pediatric endotracheal intubation involves several steps, which are summarized in the Procedure for Pediatric Endotracheal Intubation on pages 84–87 and are discussed in detail below and on the pages that follow the Procedure.

1. Before You Begin

Observe body substance isolation procedures (universal precautions) during endotracheal intubation. If possible, work with a partner who can perform assisted ventilation, hand you equipment, administer cricoid pressure, monitor the patient, and carry out related tasks while you complete the intubation. A third partner may be needed to maintain inline stabilization of the cervical spine if trauma is suspected. If you must perform intubation after transport is underway and driving conditions are likely to interfere with intubation, consider pulling over until the procedure is complete.

At this point, you will have completed enough of the initial assessment to have determined that the patient meets clinical indications for endotracheal intubation and to determine if a pharmacologically assisted intubation is indicated. Obtain a focused history, if possible, to make sure the patient does not have any contraindications to intubation or pharmacologically assisted intubation.

2. Prepare the Equipment and Medications if Needed

It is important to assure that all equipment is ready and available prior to beginning intubation. (Review the Procedure for Equipment for Pediatric Endotracheal Intubation on pages 80–83.) Once you have determined that endotracheal intubation is indicated, make sure all the necessary equipment is prepared and laid out within easy reach while continuing to oxygenate and ventilate the patient.

The mnemonic SOAPME can help you remember the general types of equipment and supplies required for intubation. The letters stand for

S Suction equipment

O Oxygen equipment

A Airway equipment

P Pharmacological agents

M Monitoring equipment

E Endotracheal-versus-esophageal detection method

CHILDREN ARE DIFFERENT

Particularly in younger children, there is only a small margin between correct endotracheal tube placement and bronchial or esophageal placement. Measurement with a length-based resuscitation tape is critical in determining correct tube size and insertion depth.

Measure the child, using a length-based resuscitation tape, to determine appropriate equipment sizing and insertion depth. Select a properly sized face mask, oropharyngeal airway, laryngoscope blade, and endotracheal tube as indicated on the tape. Also set out a laryngoscope blade in one additional size, and endotracheal tubes that are one size larger and one size smaller than the tube size indicated. Use straight laryngoscope blades when intubating younger children and infants. (See Tables 3-2 and 3-3.)

ESTIMATING ENDOTRACHEAL TUBE SIZE

In children, you can estimate the proper tube size using the following formula:

4 + (age in years/4) mm

ESTIMATING ENDOTRACHEAL TUBE INSERTION DEPTH

In children older than two years, the depth in centimeters for endotracheal tube insertion can be estimated using the following formula:

Depth = (age in years/2) plus 12

For example, in a four-year-old child, the depth would be (4 divided by 2) plus 12, or 14 cm. You will insert the tube until the 14-cm mark appears at the corner of the child's mouth.

An alternative formula, which can be used in younger children, is to multiply the inside diameter of the tube by three. For example, in a four-month-old child being intubated with a 3.5-mm tube, the depth of insertion would be 3.5 × 3, or 10.5 cm. You will insert the tube until the 10.5-cm mark appears at the corner of the child's mouth.

If the child is large enough to require a cuffed tube, check the pilot balloon and cuff for leaks. Cuffed tubes are generally indicated for children older than eight years or those requiring endotracheal tubes 6.0 mm or larger.

Assemble the laryngoscope handle and blade, then test to make sure the connections are tight and the light is working.

Select a stylet for each endotracheal tube. Insert a stylet into each endotracheal tube, but not through the tip. The tip of the stylet should be retracted about one-quarter inch from the tip of the tube, just above the level of the tube's

TABLE 3-2 Pediatric Laryngoscope Blade Selection

Age	Blade Size and Type
Newborn (≤2.0 kg)	0 Miller
Newborn (>2.0 kg)–6 months	1 Miller
6 months–2 years	1–2 Miller
2–8 years	2 Miller
8–12 years	2 Miller or 2 Macintosh
Older than 12 years	3 Miller or 3 Macintosh

Murphy eye (a hole near the tip that lessens the chance of tube obstruction). The stylet will help keep the tube from kinking during insertion, making it easier to direct the tube into the glottic opening. If the stylet extends beyond the tip of the endotracheal tube, it can puncture soft tissue structures during insertion.

Set up and test suctioning and oxygen delivery equipment. Connect the suctioning equipment to a large-bore suctioning device.

Prepare an end-tidal carbon dioxide detector. If it is an electronic model, switch it on and test it for proper function according to the manufacturer's specifications. If it is a disposable model, remove it from the packaging and inspect it for cracks or defects.

3. Initiate Monitoring

Initiate monitoring, which may include the completion of an initial assessment by another provider or attaching the patient to minimal monitoring equipment. The degree of monitoring depends on equipment and resources available. These can include continuous cardiac monitoring, pulse oximetry, automated blood pressure monitoring, and end-tidal carbon dioxide detection.

4. Position the Patient

With the equipment ready, place the patient in a supine position. If possible, the patient should be positioned on a stretcher or table with a surface slightly above your eye level, as this makes it easier to see the child's vocal cords. Properly posi-

TABLE 3-3 Pediatric Endotracheal Tube Selection

Age	Tube Size
Newborn (≤2.0 kg)	2.5 mm
Newborn (>2.0 kg)–6 months	3.0–3.5 mm
6 months–1 year	3.5–4.0 mm
1–2 years	4.0–4.5 mm
Older than 2 years	4 1 (age in years/4) mm

tioning the patient's head and neck will help you obtain a clear view of the laryngeal opening. Positioning depends on the patient's age and clinical situation.

- If no trauma is suspected: Place infants and toddlers in the neutral position by arranging a one-inch layer of padding beneath the torso from the shoulders to the hips. In preschool and school-age patients (up to about eight years old), no additional head elevation or head tilt is required to achieve the neutral position because the prominent occiput causes the neck to be slightly flexed when the patient is supine. Place older children and adolescents in the sniffing position by elevating the head 8 to 10 cm and tilting it backward at the atlantooccipital joint. Obese adolescents may require padding under the shoulders as well as the head to achieve this position.
- If trauma is suspected: Use the neutral position for patients who may have injuries involving the head, neck, or spine. Have a partner provide in-line stabilization while standing just to your left. If applicable, remove the front of the cervical collar so that you can open the jaw and apply cricoid pressure.

CLINICAL PEARLS

To perform endotracheal intubation, it is best to position yourself by the patient's head. Keeping your hands and face at the same level as the patient's head will result in the clearest view.

Position yourself by the patient's head. Keeping your hands and face at the same level as the patient's head will result in the clearest view.

5. Preoxygenate and Ventilate the Patient

CLINICAL PEARLS

To reduce the risk of hypoxemia, all patients should receive oxygenation prior to intubation.

To reduce the risk of hypoxemia, all patients should receive oxygenation prior to intubation. Use a nonrebreather mask, if possible, as this will hyperoxygenate and does not carry the complication of gastric distension that the bag-valve mask can cause. If the patient is unable to breathe spontaneously, use a BVM device. Administer high-concentration oxygen for at least thirty seconds. An oropharyngeal airway can be inserted in the unconscious patient, if necessary, to ensure an airway to ensure thorough oxygenation, but it must be removed before proceeding further.

6. Suction the Patient if Necessary

Suction the patient's mouth and visible pharynx to clear secretions, if present. Ventilate again for at least thirty seconds if the patient is suctioned.

7. Premedicate the Patient if Indicated

DRUG REFERENCE

Preparatory drugs for endotracheal intubation may include atropine, glycopyrrolate, or lidocaine.

In some cases, the patient may require premedication with atropine, glycopyrrolate or lidocaine. Consult medical direction or follow regional protocols.

- In young children, endotracheal intubation can initiate a strong vagal stimulus and cause bradycardia. The best method of preventing these effects is through adequate preoxygenation. To further reduce these effects, some systems use premedication with atropine for all children younger than one year, children who are bradycardic, and children younger than five years who will be receiving succinylcholine as the paralytic agent. Atropine should also be given to adolescent patients who receive a second dose of succinylcholine. Dosage is 0.02 mg/kg (minimum dose 0.1 mg; maximum dose 0.5 mg).
- Secretions can make visualization and intubation difficult. Some regional protocols may call for either atropine (0.02 mg/kg, minimum dose 0.1 mg and maximum dose 0.3 mg) or glycopyrrolate (0.005–0.01 mg/kg, maximum dose 0.2 mg)
- Lidocaine is recommended as part of the neurosurgical induction for patients who have head trauma to blunt the increased intracranial pressure and laryngeal reactivity seen with intubation. Dosage is 1.0 to 1.5 mg/kg.

From this point, the rest of the intubation should be completed and ventilation resumed in no more than 20 seconds.

8. Perform a Sellick Maneuver

To enhance your view and prevent problems during intubation, your partner should use a Sellick maneuver that involves applying gentle pressure to the cricoid cartilage just below the thyroid cartilage. This procedure temporarily occludes the esophagus by compressing it between the cricoid cartilage and the cervical vertebrae. It minimizes gastric inflation and helps to prevent passive regurgitation of stomach contents, reducing the likelihood of aspiration. Avoid applying excessive pressure, which can obstruct the trachea. Note that once pressure has been applied, it must be maintained until proper tube placement is confirmed.

9. Sedate the Patient if Indicated

The ideal sedative should have rapid onset and minimal side effects. The most commonly used sedatives are thiopental, ketamine, etomidate, fentanyl, midazolam, and propofol. Many of these agents are not common to prehospital care and may only be carried for pharmacologically assisted intubation. In some systems, while less ideal, the sedative used is diazepam because it is a medication already carried. The specific choice is influenced by numerous factors including bronchospasm, hypotension, and age of the patient.

If a paralytic was used, the patient should never be awake while paralyzed. It is critical to ensure that adequate sedation is provided for the duration of paralysis. Select a sedative with a duration of effect as long or longer than that of the paralytic agent to be used or be prepared to administer additional sedation. For characteristics of sedative agents, see Table 3-4.

Additional comments:

Ketamine is unique among the induction agents because it will actually increase heart rate and blood pressure for most patients. It also is a potent bronchodilator and increases the plasma concentration of catecholamines.

CLINICAL PEARLS

Once preparatory drugs have been administered, the rest of the intubation should be completed and ventilation resumed in no more than 20 seconds.

DRUG REFERENCE

Sedative drugs may include thiopental, ketamine, etomidate, fentanyl, midazolam, or propofol.

CLINICAL PEARLS

The patient should never be awake while paralyzed. Adequate sedation must be provided for the duration of paralysis.

DRUG REFERENCE

Ketamine effects include increased heart rate, increased blood pressure, bronchodilation, increased catecholamine concentration, increased intracranial pressure, and frightening dreams on emergence.

TABLE 3-4 Characteristics of Sedative Agents

Agent	Dose (IV/IO)	Onset	Duration	Adverse Effects
Thiopental	2.0–4.0 mg/kg	10–20 sec	5–10 min	Respiratory depression, hypotension
Ketamine	1.0–2.0 mg/kg	1–2 min	10–30 min	Secretions, increased intraocular and intracranial pressure, increased blood pressure, emergence reactions
Etomidate	0.2–0.3 mg/kg	1 min	3–12 min	Respiratory depression, fasciculations
Fentanyl	2.0–4.0 mcg/kg	1 min	1–2 hours	Respiratory depression, hypotension
Midazolam	0.1–0.2 mg/kg	1–2 min	1–2 hours	Respiratory depression, hypotension but less than other agents
Propofol	2.0–2.5 mg/kg	30–60 sec	10–15 min	Respiratory depression, hypotension

DRUG REFERENCE

Etomidate is neuroprotective with no significant effect on heart rate or blood pressure. It may cause muscle fasciculations in patients who are near death.

These factors make it useful for patients with asthma or hypotension. Premedicate with atropine to offset secretions. Emergence reactions may involve vivid, sometimes frightening dreams. Ketamine can increase intracranial pressure and should be used with caution in patients with head trauma.

Etomidate is neuroprotective and generally has no significant effect on heart rate or blood pressure. Muscle fasciculations (twitches) have been noted in patients who are in extremis (at the point of death).

KEY TERMS

DEPOLARIZING AGENT paralytic agent that binds to a muscle receptor site, causes muscle contraction, and then continues to occupy the receptor site, preventing further contractions.

NONDEPOLARIZING AGENT paralytic agent that binds to a muscle receptor site without causing a contraction and continues to occupy the receptor site and prevent contractions.

10. Administer a Paralytic Agent if Indicated

The ideal paralytic would have rapid onset and a short duration of effect with minimum significant side effects or drug interactions. Paralytic agents frequently used for pharmacologically assisted intubation include succinylcholine, a depolarizing agent; and rocuronium and vecuronium, which are nondepolarizing agents. The major differences among the nondepolarizing agents are in peak onset and length of action. For characteristics of paralytic agents, see Table 3-5.

Additional comments:

Succinylcholine causes depolarization of the neuromuscular junction and muscle fasciculations prior to full neuromuscular blockade and paralysis. It also increases vagal tone, which can increase secretions and cause bradycardia. If given intramuscularly, double the dose. Other adverse effects include increased ocular, gastric, and intracranial pressure. Succinylcholine may cause hyperkalemia (excessive blood potassium).

DRUG REFERENCE

Succinylcholine causes muscle fasciculations before paralysis, may cause bradycardia, may increase secretions, ocular, gastric, and intracranial pressure, and hyperkalemia.

11. Open the Mouth and Control the Tongue and Epiglottis

In patients with limp muscle tone, particularly infants, the mouth can be opened by pushing the jaw forward or by simply inserting the laryngoscope blade. Other patients may require a cross-finger or scissors technique: Use your first and second or first and third fingers to push the upper and lower teeth apart. Be cautious when placing your fingers in the mouth of any patient who is not fully comatose. Prior to intubation, the tongue and epiglottis must be controlled using the flange and tip of the laryngoscope blade.

Grasp the laryngoscope handle in the left hand, close to the blade. For infants and toddlers, a lighter grip is preferred. Hold the handle between the thumb and

TABLE 3-5 Characteristics of Paralytic Agents

Characteristics of Paralytic Agents			
Agent	Dose	Onset	Duration
Succinylcholine	2.0 mg/kg > 10 kg or > 12 mo	30–60 sec	3–5 min
	1.0mg/kg < 10 kg or < 12 mo	30–60 sec	3–5 min
Rocuronium	0.6 mg/kg (low range)	60–90 sec	30–40 min
	1.2 mg/kg (high range)	30–60 sec	60–90 min
Vecuronium	0.1 mg/kg (low range)	2–3 min	30–60 min
	0.2 mg/kg (high range)	30–90 sec	90–120 min

the first two fingers to maintain a lighter touch. Use the fingertips rather than the whole hand to control movements.

Insert the laryngoscope blade into the right side of the child's mouth. Be careful not to press against the teeth or gums with the blade. Advance the blade along the tongue, directing the blade toward the center of the mouth so that the tongue is pushed upward and toward the left side of the mouth. Laryngeal view will be down the right side of the tongue, while the tongue and jaw are lifted upward and forward along the line of the laryngoscope handle. If the blade is incorrectly passed down the middle of the tongue, the tongue will flop over both sides of the blade, narrowing your field of view and complicating passage of the endotracheal tube.

Direct gentle force upward along the handle at a 45-degree angle as you insert the blade. Never lever the handle or blade against the teeth and gums, because this can cause trauma. Advance the blade slowly along the tongue until it reaches the epiglottis. If the blade is advanced too quickly, particularly when intubating smaller patients, the blade may bypass the epiglottis and be inserted directly into the esophagus.

If you are using a straight laryngoscope blade, gently lift the epiglottis with the tip of the blade and move it forward. To avoid inadvertent esophageal placement, it is critical to place the blade so that the epiglottis is lifted completely up and away from the airway opening. This permits an unobstructed view of the vocal cords so that the tube can be passed easily into the trachea.

If you are using a curved blade, place the tip in the vallecula and lift the epiglottis indirectly by applying pressure on the hyoepiglottic ligament located beneath the vallecula.

NOTE: Depending on the depth of blade insertion, you may occasionally pick up the epiglottis directly using a curved blade, or a straight blade may sometimes be placed in the vallecula. While this should not be your goal, if it does happen and as long as you obtain a good laryngeal view, these instances do not necessarily pose a problem.

12. Locate Landmarks for Intubation

Before inserting the endotracheal tube, you must obtain a clear view of the glottic opening so that you can identify the entrance to the larynx. Always proceed from one recognized structure to the next. Never blindly advance the entire laryngoscope into the mouth. The key to successful intubation is landmark identification. If you cannot identify a landmark do not proceed. Withdraw the tube and blade and ventilate the patient. It is better to ventilate with a BVM and attempt again than to incorrectly place the endotracheal tube.

CLINICAL PEARLS

Before inserting the endotracheal tube, you must obtain a clear view of the glottic opening so that you can identify the entrance to the larynx.

KEY LANDMARKS

The area between the tongue and epiglottis is the vallecula. The epiglottis is located at the base of the tongue and defines the laryngeal inlet, making it the principal landmark for the structures that surround the entrance of the larynx. The aryepiglottic folds, located on each side of the epiglottis, tilt inferiorly and posteriorly toward the posterior cartilages. Between the posterior cartilages on each side is the interarytenoid notch. The glottic opening lies anterior to the posterior cartilages and marks the entrance to the larynx. Pressing the laryngoscope blade against the tongue and vallecula or epiglottis usually gives the glottic opening either a narrow, slitlike appearance or a somewhat triangular shape.

Within the larynx itself are the false vocal cords, or vestibular folds, and the true vocal cords, which are white and should be easy to distinguish. In the spontaneously breathing patient, you may see the true vocal cords opening and closing. The esophagus appears as a round, dark hole just below the posterior cartilages and the interarytenoid notch. Be sure to identify these structures so that you can direct the tube into the laryngeal opening above them. Failure to confirm these landmarks almost always results in esophageal intubation.

13. Insert the Endotracheal Tube

Actual insertion of the endotracheal tube should go smoothly as long as you keep the opening between the vocal cords in view throughout placement. Hold the tube just above the marking that corresponds to the correct insertion depth as previously determined. Check to make sure the patient's vocal cords are open. If they are closed, wait for them to open before advancing the tube. Insert the tube gently at the right-hand corner of the patient's mouth so that your view of the laryngeal opening is not obscured by the tube.

Guide the tube through the opening between the vocal cords while continuing to control the tongue with the laryngoscope blade. It is critical to observe the tip of the tube as it passes above the posterior cartilages and interarytenoid notch and between the vocal cords. Losing sight of it at the last moment is a frequent cause of esophageal placement. Continue passing the tube until the marking for the proper depth is level with the patient's vocal cords. When the endotracheal tube is in place, hold it firmly against the lip at the right corner of the child's mouth and withdraw the laryngoscope. Slip the stylet out of the endotracheal tube. Attach the BVM to the endotracheal tube and resume assisted ventilation through the tube.

Never force the tube. If you cannot advance the tube into the glottic opening, it may be helpful to partially withdraw the stylet. If this does not help, the tube may be too large to pass through the child's narrow cricoid ring. Withdraw the tube and either immediately attempt with a smaller tube or begin assisted ventilations and then begin again with a smaller tube.

14. Resume Oxygenation and Ventilation

As soon as the tube is placed, promptly resume oxygenation and ventilation.

15. Confirm Correct Placement

CLINICAL PEARLS

Confirmation of tube placement is critical. If you cannot confirm correct placement, immediately withdraw the tube and provide assisted ventilation.

Confirmation is probably the most critical step in intubation. Although it is important to correctly place the tube, occasionally there may be an incorrect placement. Incorrect placement is a catastrophic event only if unrealized. If you cannot positively confirm proper placement, withdraw the tube and use BVM ventilation. With the endotracheal tube in place, hold the tube securely against the patient's upper lip and check placement, using clinical assessment techniques and confirmatory devices.

Clinical assessment includes the following:

- Bilateral chest expansion (chest rise)
- Bilateral and equal breath sounds
- Absence of air when auscultating over the stomach
- Improvement in patient condition
- Improved heart rate
- Improved skin color
- Improved mental status

Watch for equal chest rise bilaterally while continuing assisted ventilation with the bag-valve device. Position a stethoscope over the upper abdomen and auscultate for a gurgling sound in the stomach. This sound indicates esophageal intubation. If noted, the tube should be removed. Auscultate for breath sounds in the chest at the second or third intercostal space in the mid-axillary line.

Compare breath sounds bilaterally. Greatly reduced breath sounds on the left side may indicate that the endotracheal tube has been placed in the right main-

stem bronchus. To correct this problem, listen over the left chest while pulling the tube slowly outward until the breath sounds are equal to the right side. Note that breath sounds tend to travel more easily through a child's chest than an adult's, so you may still hear breath sounds in the axillary regions when the tube is incorrectly placed. Watch the child's skin color to see if cyanosis gives way to pale or pink color. If the child was bradycardic, check to see if the heart rate has returned to the normal range.

After you have completed these clinical assessments, verify oxygenation through pulse oximetry and assess for esophageal intubation, using an end-tidal carbon dioxide device. These measures are important adjuncts to clinical assessment. The presence of carbon dioxide during expiration helps to confirm that the tube is properly positioned: Because the stomach does not produce carbon dioxide, this gas is not present when the tube is placed in the esophagus. Leave the detector in place because it will provide an early indication if the tube later becomes obstructed or dislodged.

16. Secure the Tube

Once you have confirmed proper positioning, hold the endotracheal tube firmly in place and tape it above, below, and to the side of the right corner of the child's mouth, or secure the tube with a commercial endotracheal tube holder.

17. Reconfirm Correct Placement

During the securing process, the tube may have moved. For this reason, reconfirm placement as you did to confirm the initial placement.

18. Ensure Adequate Sedation for Prolonged Paralysis

If paralysis was used and is still present, continue sedation as discussed in the sedation section.

19. Continue Monitoring Correct Placement

Because a pediatric endotracheal tube is short, slight movement can displace the tube from the trachea and into either the right main stem bronchus or the esophagus. This will be a problem only if it is not noticed. Throughout further care and transport, continually reassess the patient for continued correct endotracheal tube placement.

In addition if the intubated patient has a change in condition, part of the patient assessment should include assessing the endotracheal tube for a problem. A useful acronym for remembering the items to assess in the intubated patient with a change in condition is DOPE. This stands for:

Dislodgment of the tube

Obstruction of the tube

Pneumothorax

Equipment failure such as of BVM or oxygen source

Alternative Airways

Several types of alternative airways are now available. None secure the airway as definitively as an endotracheal tube but all can be inserted without direct visualization with a laryngoscope, require less training to insert than the endotracheal tube, and provide a means of protecting the airway and ventilating the patient. (See the Procedure for Alternative Airways on pages 88–89.)

PROCEDURE ■ Airway Positioning

FIGURE 3-1A

Place the patient in a supine position with a small towel under the shoulders (or shoulders to pelvis under age two) to level the plane of the airway.

FIGURE 3-1B

A modified jaw thrust maneuver to open the airway in an infant with suspected trauma.

FIGURE 3-1C

A head-tilt-chin-lift maneuver to open the airway in an infant with no suspected trauma.

FIGURE 3-1D

A jaw thrust may be performed to open the airway in a child.

FIGURE 3-1E

A modified jaw thrust maneuver keeps head and spine aligned in a child with suspected trauma.

FIGURE 3-1F

A head-tilt-chin-lift maneuver to open the airway in a child with no suspected trauma.

PROCEDURE ■ Airway Clearance—Conscious Infant (> 1 Year)

To clear a foreign body airway obstruction in a conscious infant (1 year old or less), follow these steps:

1. Pick up the infant and straddle him over one of your arms, with the face down and the head lower than the trunk. Support the head with your hand and rest your forearm holding the infant on your thigh.
2. Deliver five back blows with the heel of the other hand. Deliver these forcefully and rapidly between the shoulder blades (Figure 3-2a).
3. If the foreign body is yet not expelled, sandwich the infant between your forearms and roll the infant so he is now supine on your other forearm. Then rest the forearm supporting the infant on your thigh with the head lower than the trunk.
4. Deliver five chest thrusts with your fingers in the same position (lower sternum) as CPR compressions. Deliver these also in the same rapid and sharp fashion as the previous back blows (Figure 3-2b).
5. If the patient becomes unconscious, follow the procedure for an unconscious infant with an airway obstruction.

FIGURE 3-2A

To clear an airway obstruction in an infant less than one year old, deliver five back blows…

FIGURE 3-2B

…followed by five chest thrusts.

PROCEDURE ■ Airway Clearance—Unconscious Infant (> 1 Year)

To clear a foreign body airway obstruction in an unconscious infant (1 year old or less), or in an infant who becomes unconscious during the airway removal procedure, follow these steps:

1. Place the infant supine and open the airway manually to assess for breathing.
2. If breathing is absent, attempt to ventilate once. If blocked, reposition the head and airway manually and attempt to ventilate again.
3. Pick up the infant and straddle him over one of your arms, with the face down and the head lower than the trunk. Support the head with your hand and rest your forearm holding the infant on your thigh.
4. Deliver five back blows with the heel of the other hand. Deliver these forcefully and rapidly between the shoulder blades. (Review Figure 3-2a in the procedure for a conscious infant.)
5. If the foreign body is yet not expelled, sandwich the infant between your forearms and roll the infant so he is now supine on your other forearm. Then rest the forearm supporting the infant on your thigh with the head lower than the trunk.

(continued)

PROCEDURE ■ Airway Clearance—Unconscious Infant (continued)

6. Deliver five chest thrusts with your fingers in the same position (lower sternum) as CPR compressions. Deliver these also in the same rapid and sharp fashion as the previous back blows. (Review Figure 3-2b in the procedure for a conscious infant.)
7. Reassess the airway by looking in the mouth for the obstruction (never do a blind finger sweep), and pluck it out if seen. Reattempt to ventilate.
8. Repeat steps 3 through 7 until the airway is cleared or until you have laryngoscopy equipment ready.
9. Perform visual laryngoscopy for the foreign body, and retrieve it by using pediatric Magill forceps. Reattempt to ventilate.
10. If you cannot ventilate, attempt to intubate. (If necessary, you may be able to push object into right mainstem bronchus and then ventilate the left lung.)
11. If still obstructed, consider performing a needle cricothyrotomy if the personnel, equipment, and permission from medical direction to do so are available and granted.

PROCEDURE ■ Airway Clearance—Conscious Child (over 1 year old)

To clear a foreign body airway obstruction in a conscious child over one year old, follow these steps:

1. If the patient can forcefully cough, encourage him to continue his own efforts to remove the foreign body.
2. If the patient cannot forcefully cough or speak, stand behind him, lower yourself to his height, and circle your arms around the child so that your hands can be clenched over the abdomen.
3. Place a clenched fist (with the thumb to the inside of the fist), just superior to the umbilicus and well below the xyphoid process.
4. Deliver subdiaphragmatic thrusts with an inward-upward motion. Each thrust should be its own distinct motion and never come into contact with the lower ribcage or xyphoid process during the delivery of the abdominal thrusts. This procedure is commonly known as the Heimlich maneuver (Figure 3-3).
5. Repeat the thrusts until the patient expels the foreign body or becomes unconscious.
6. If the patient becomes unconscious, follow the procedure for an unconscious child with an airway obstruction—after first visualizing the airway for the foreign body, because it may become dislodged during the movement of the patient to the floor after he becomes unconscious.

FIGURE 3-3

To clear an airway obstruction in a conscious child, perform abdominal thrusts (the Heimlich maneuver).

PROCEDURE ■ Airway Clearance—Unconscious Child (over 1 year old)

To clear an airway obstruction in an unconscious child over one year old, or in a child who becomes unconscious during the airway removal procedure, follow these steps:

1. Place the patient supine and open the airway manually to assess for breathing.
2. If breathing is absent, attempt to ventilate once. If blocked, reposition the head and airway manually and attempt to ventilate again.
3. With the patient lying supine, straddle the patient's hips and place the heel of one hand on the abdomen, directly superior to the umbilicus and well below the xyphoid process. Interlace your other hand on top of the first.
4. Deliver five subdiaphragmatic thrusts in a quick, upward motion (Figure 3-4). Each thrust should be its own distinct movement. Aim thrusts midline, and not off to either side.
5. Perform a manual airway technique to open the mouth and inspect for the foreign body. Reassess the airway by looking in the mouth for the obstruction (never do a blind finger sweep), and pluck it out if seen. Reattempt to ventilate.
6. Repeat steps 3 through 5 until the airway is cleared or until you have laryngoscopy equipment ready.
7. Perform visual laryngoscopy for the foreign body, and retrieve it by using pediatric Magill forceps. Reattempt to ventilate.
8. If you cannot ventilate, attempt to intubate. (If necessary, you may push the object into the right mainstem bronchus and then ventilate the left lung.)
9. If still obstructed, consider performing a needle cricothyrotomy if the personnel, equipment, and permission to do so from medical direction are available and granted. (See the Procedure for Needle Cricothyrotomy on pages 76–77.)

FIGURE 3-4

To clear an airway obstruction in an unconscious child, place the child in a supine position and perform abdominal thrusts.

PROCEDURE ■ Needle Cricothyrotomy

If airway clearance procedures have failed, needle cricothyrotomy may be performed if it is permitted by medical direction and if you are trained appropriately.

FIGURE 3-5A

Lay out the equipment.

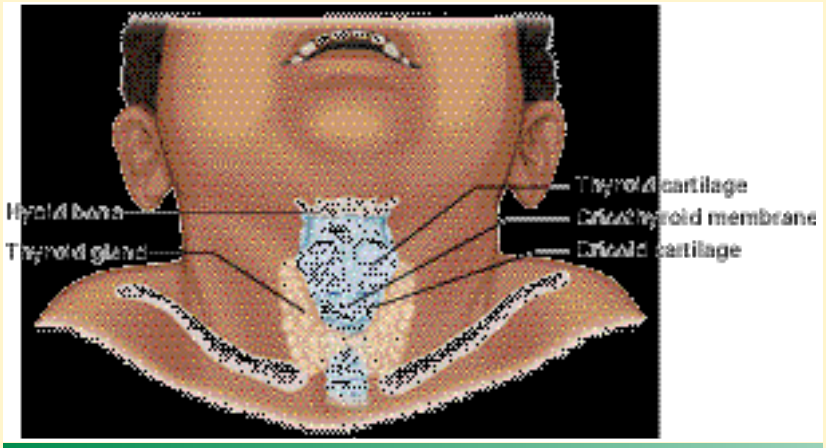

FIGURE 3-5B

To perform a needle cricothyrotomy, first locate the cricothyroid membrane, which lies between the thyroid cartilage and the cricoid cartilage.

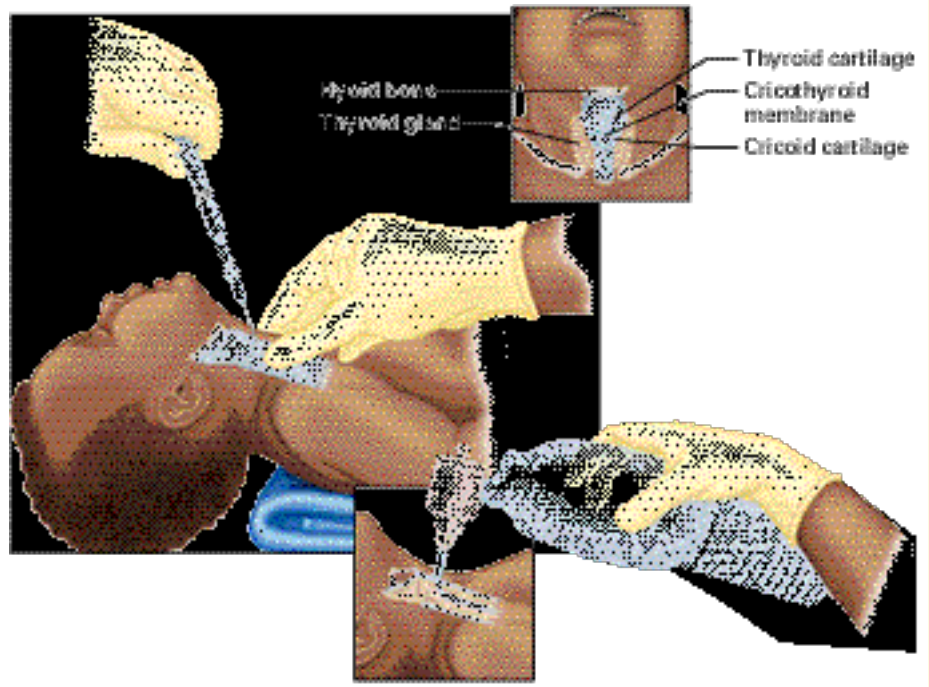

FIGURE 3-5C

Swab the anterior neck with antiseptic. Attach a 14- to 16-gauge over-the-needle catheter to a 3- to 5-mL syringe. Carefully insert the needle—at a 90-degree angle or at a slight angle toward the feet—through the cricothyroid membrane and no more than 1 centimeter into the trachea. Maintain negative pressure (pulling back on the plunger) while inserting. A return of air indicates that the needle is in the trachea. If there is resistance or a return of blood, adjust the placement. Once placement is confirmed, check for spontaneous ventilations. If ventilations are absent or inadequate, connect a positive-pressure ventilating device to the catheter. Ventilate the patient, monitoring carefully for chest rise.

FIGURE 3-5D

Prepare to insert the needle.

FIGURE 3-5E

Catheter in place.

PROCEDURE ■ Oropharyngeal Airway

For unconscious patients, an oropharyngeal airway adjunct can be used to control the airway and keep the tongue from falling back against the posterior pharynx.

FIGURE 3-6A

A variety of oropharyngeal airways.

FIGURE 3-6B

Sizing an oropharyngeal airway.

FIGURE 3-6C

Inserting an oropharyngeal airway using a tongue depressor.

FIGURE 3-6D

An oropharyngeal airway in place.

PROCEDURE ■ Nasopharyngeal Airway

Nasal airways are appropriate for conscious children who cannot maintain an open airway. They should not be used in children with facial trauma or head injuries.

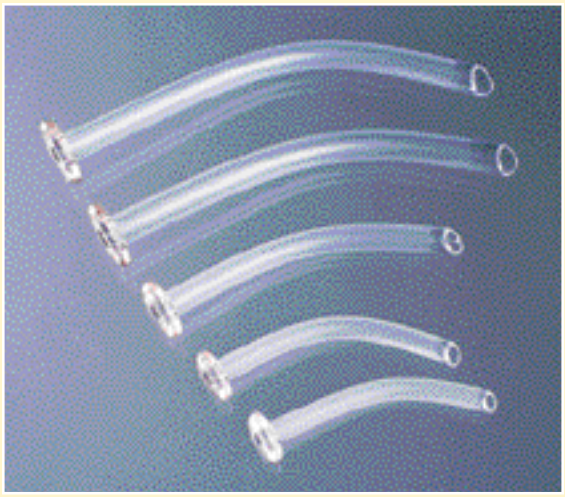

FIGURE 3-7A

Nasopharyngeal airways in a variety of pediatric and adult sizes.

FIGURE 3-7B

Sizing a nasopharyngeal airway.

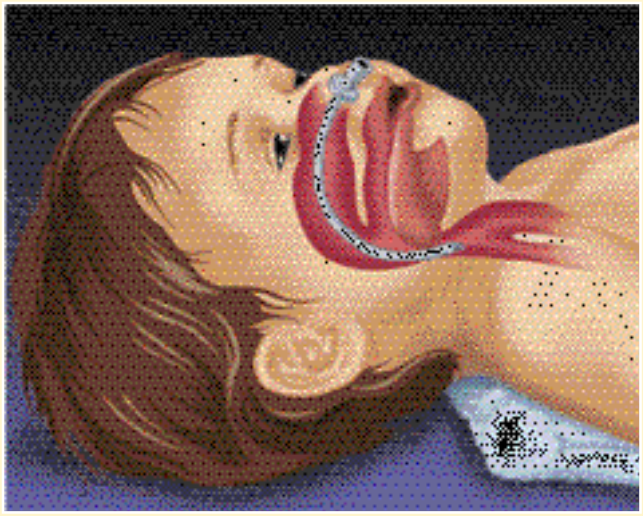

FIGURE 3-7C

A nasopharyngeal airway in place.

PROCEDURE ■ Equipment for Pediatric Endotracheal Intubation

The equipment shown here, necessary to perform an endotracheal intubation in a pediatric patient, should be stored in an easily accessible equipment bag.

FIGURE 3-8A

Large-bore and endotracheal suction catheters, tubing, and vacuum source.

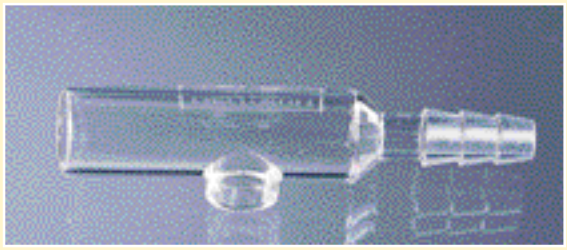

FIGURE 3-8B

Meconium aspirator (essential for newborns when meconium is present).

FIGURE 3-8C

Bag-valve-mask devices in all appropriate sizes, with oxygen attachments.

FIGURE 3-8D

Pediatric oropharyngeal airways in all appropriate sizes.

FIGURE 3-8E

Pediatric laryngoscope handle with extra batteries.

PROCEDURE ■ Equipment for Pediatric Endotracheal Intubation (continued)

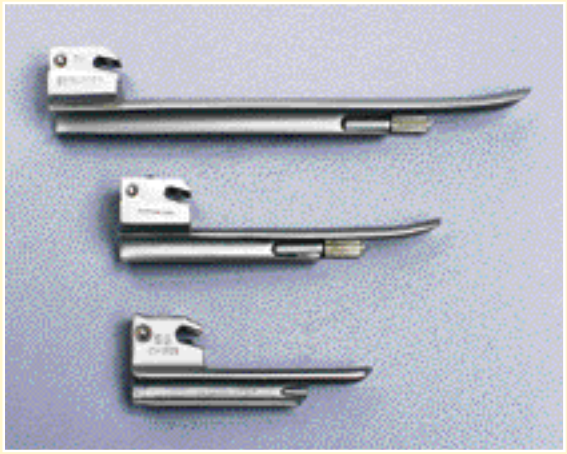

FIGURE 3-8F

Straight (Miller) laryngoscope blades in sizes 0 to 3 with extra bulbs.

FIGURE 3-8H

Pediatric endotracheal tube stylets in small and large sizes.

FIGURE 3-8J

Endotracheal tubes with cuffs in sizes 6.0 to 8.0 mm.

FIGURE 3-8G

Curved (Macintosh) laryngoscope blades in sizes 0 to 3 with extra bulbs.

FIGURE 3-8I

Uncuffed pediatric endotracheal tubes in sizes 2.5 to 5.5 mm.

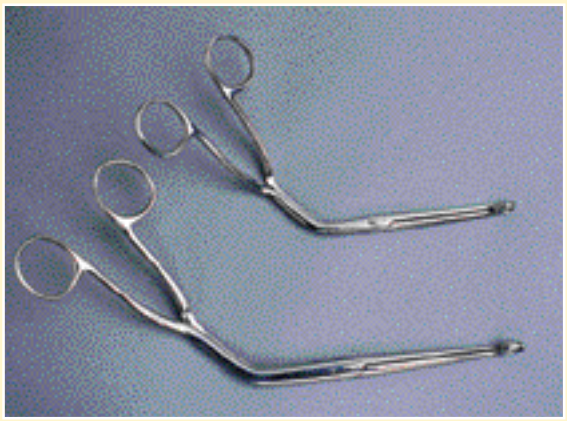

FIGURE 3-8K

Magill forceps in pediatric and adult sizes.

(continued)

PROCEDURE ■ Equipment for Pediatric Endotracheal Intubation (continued)

FIGURE 3-8L

Pulse oximeter.

FIGURE 3-8M

End-tidal carbon dioxide detection device. [Nellcor, A Division of Tyco Health Care, Inc. (top and bottom right)]

PROCEDURE ■ Equipment for Pediatric Endotracheal Intubation (continued)

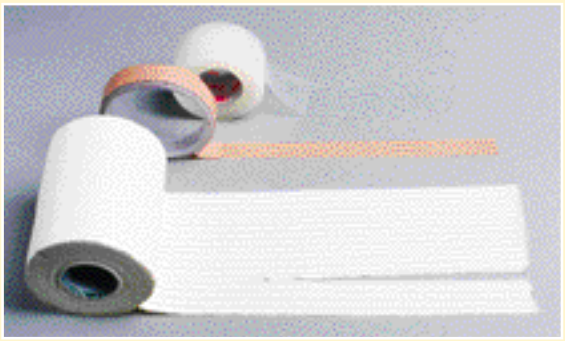

FIGURE 3-8N

Adhesive tape or other devices to secure the endotracheal tube.

FIGURE 3-8O

Length-based resuscitation tape. (Armstrong Medical)

PROCEDURE ■ Pediatric Endotracheal Intubation

To perform a pediatric endotracheal intubation, follow these steps:

1. Before you begin, take body substance isolation and plan your procedure. Perform a focused history.
2. Prepare the equipment and medications (if needed).
3. Initiate monitoring.
4. Position the patient (Figures 3-9 a to c).
5. Preoxygenate and ventilate the patient.
6. Suction the patient if necessary.
7. Premedicate the patient (if indicated).
8. Perform a Sellick maneuver (Figures 3-9 d to g).
9. Sedate the patient (if indicated).
10. Administer a paralytic agent (if indicated).
11. Open the patient's mouth and control the patient's tongue and epiglottis (Figures 3-9 h to l).
12. Locate landmarks for intubation (Figures 3-9 m and n).
13. Insert the endotracheal tube (Figures 3-9 o and p).
14. Resume oxygenation and ventilation.
15. Confirm correct placement with clinical exam and end-tidal CO_2 detection (Figure 3-9 q).
16. Secure the tube (Figures 3-9 r and s).
17. Reconfirm correct placement.
18. Ensure adequate sedation for prolonged paralysis.
19. Continue monitoring the endotracheal tube for continued correct placement.

FIGURE 3-9A

An infant positioned for intubation.

FIGURE 3-9B

A child positioned for intubation.

FIGURE 3-9C

Hold in-line stabilization during intubation if trauma is suspected.

PROCEDURE ■ Pediatric Endotracheal Intubation (continued)

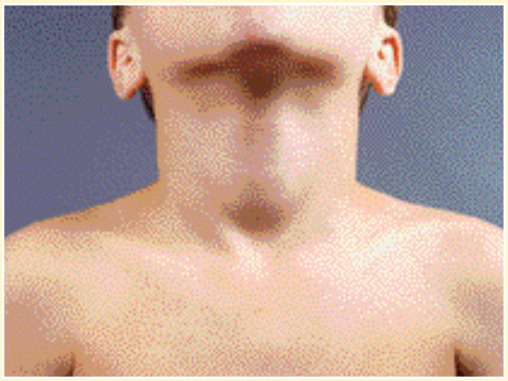

FIGURE 3-9D

To perform a Sellick maneuver, observe the anatomy of the neck to locate the cricoid cartilage.

FIGURE 3-9G

The Sellick maneuver performed on a child.

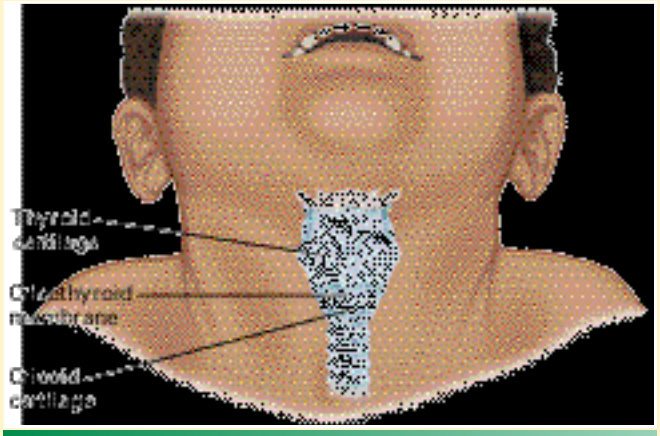

FIGURE 3-9E

The cricoid cartilage lies below the thyroid cartilage and the cricothyroid membrane.

FIGURE 3-9H

Airway positioning for intubation.

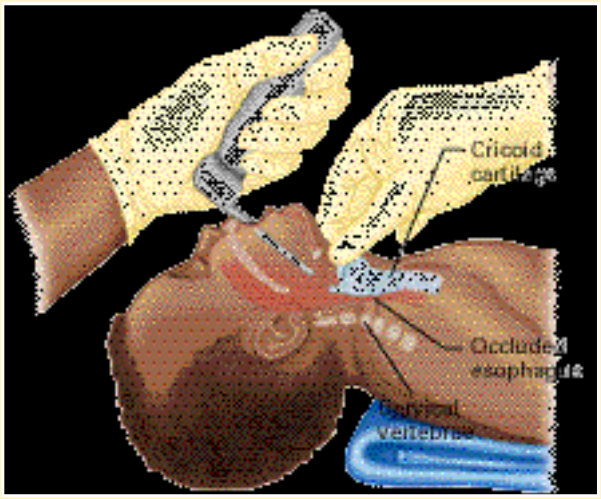

FIGURE 3-9F

Apply sufficient pressure to the cricoid cartilage to occlude the esophagus that lies behind the trachea.

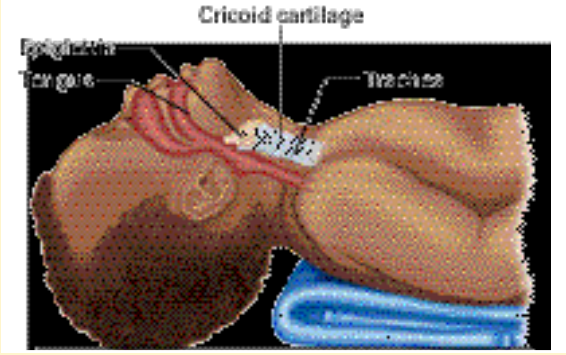

FIGURE 3-9I

Airway in position for intubation (side view).

(continued)

PROCEDURE ■ Pediatric Endotracheal Intubation (continued)

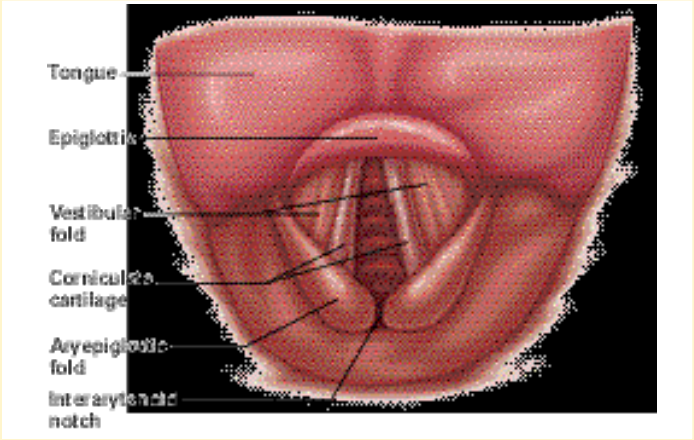

FIGURE 3-9J

Airway in position for intubation (front view).

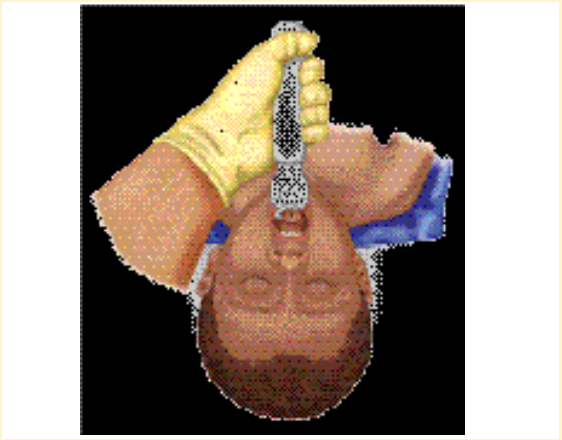

FIGURE 3-9L

Laryngoscope in place for intubation (front view).

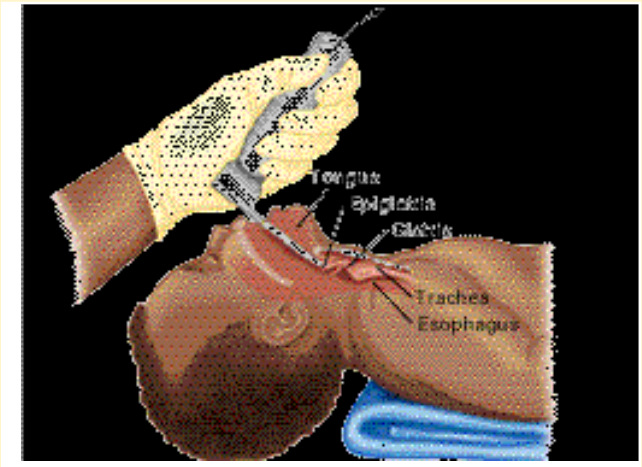

FIGURE 3-9K

Laryngoscope in place for intubation, controlling the patient's tongue and epiglottis (side view).

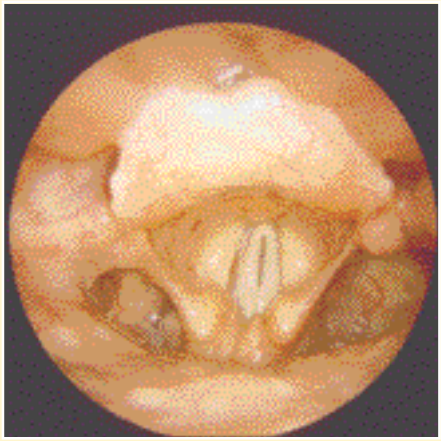

FIGURE 3-9M

The glottic opening.

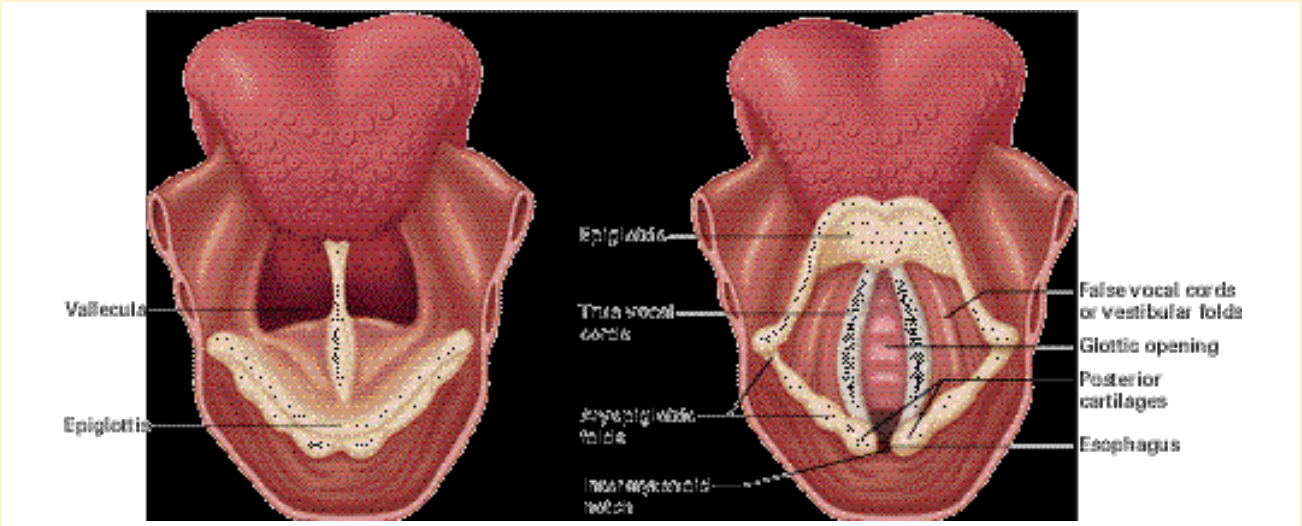

FIGURE 3-9N

Key landmarks for intubation.

PROCEDURE ■ Pediatric Endotracheal Intubation (continued)

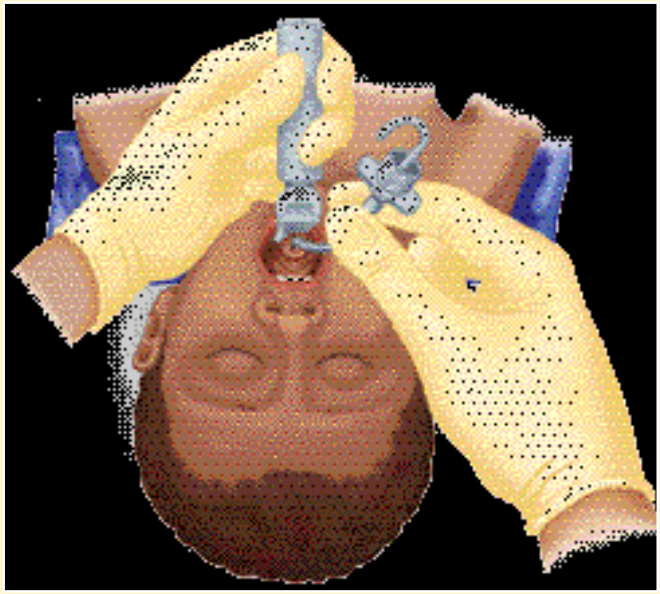

FIGURE 3-9O

Placing the endotracheal tube.

FIGURE 3-9Q

A disposable end-tidal CO_2 detector is used to detect correct placement in the trachea. (Nellcor, A Division of Tyco Healthcare, Inc.)

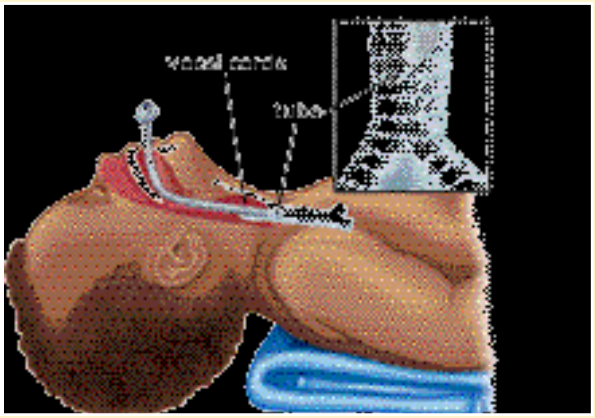

FIGURE 3-9P

The endotracheal tube in place.

FIGURE 3-9R

Tube secured.

FIGURE 3-9S

Tube secured with bag-valve mask and end-tidal CO_2 detector in place.

PROCEDURE ■ Alternative Airways

Several types of alternative airways are available that offer some degree of airway protection during ventilation.

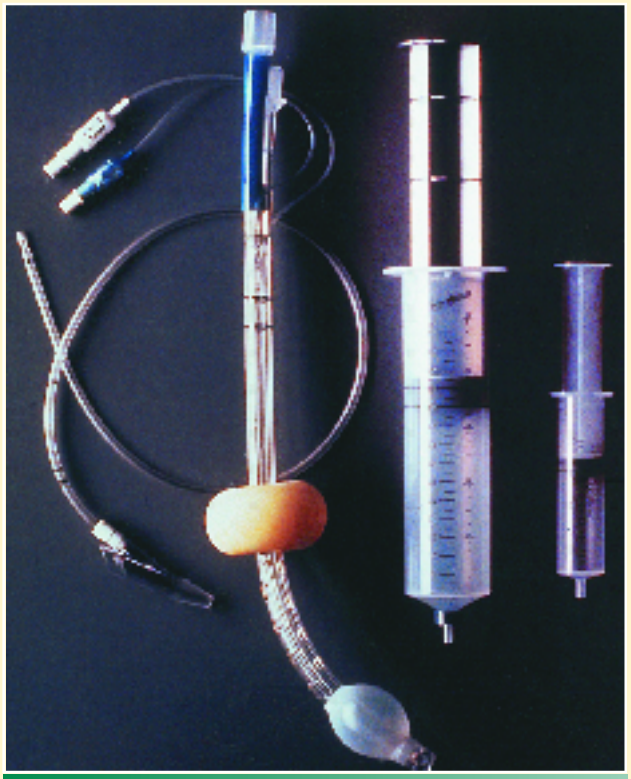

FIGURE 3-10A

The Esophageal Tracheal Combitube® (ETC) airway. NOTE that the Combitube® is contraindicated in patients who are less than 16 years of age or under 5 feet tall. It can be used in adolescents who exceed those minimum indications.

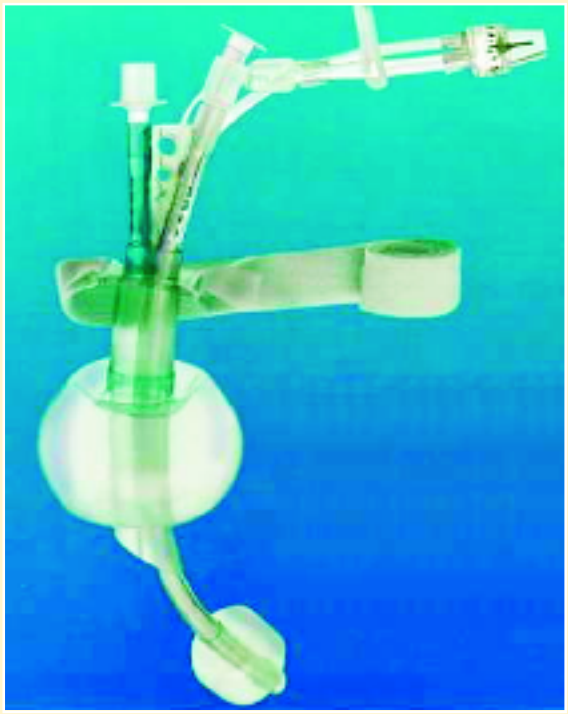

FIGURE 3-10C

The Pharyngeotracheal-lumen (PtL®) airway. NOTE that, like the Combitube®, the PtL® is contraindicated in patients who are less than 16 years of age or under 5 feet tall. It can be used in adolescents who exceed those minimum indications. (Gettig Pharmaceutical Instrument Company)

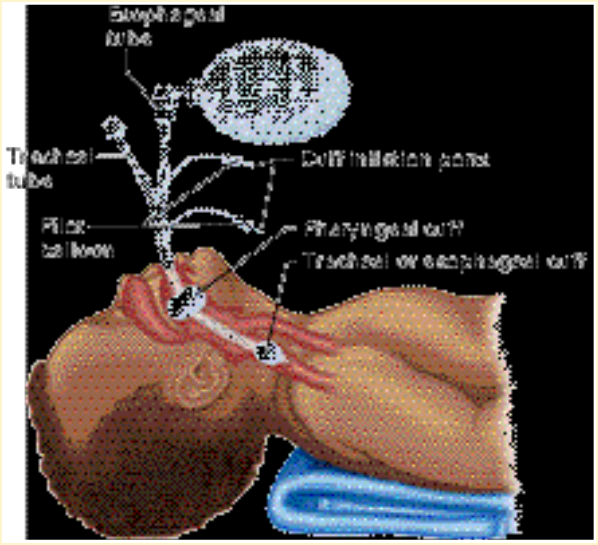

FIGURE 3-10B

The Combitube® (ETC) can be placed in either the esophagus or the trachea. Auscultation of breath sounds confirms which placement has been made. A tube can then be chosen that will direct ventilations into the trachea, whether the airway placement is esophageal or tracheal.

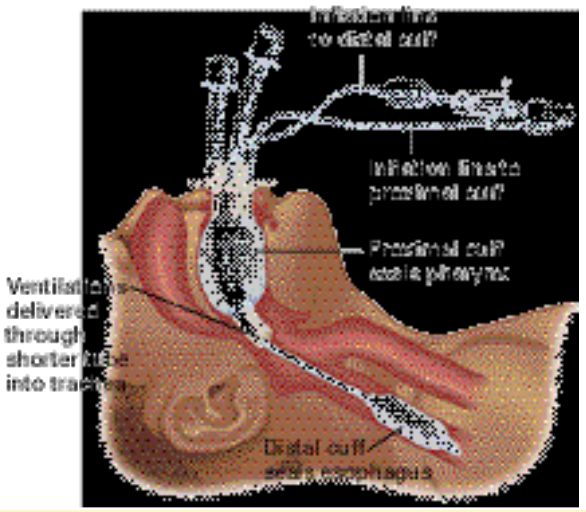

FIGURE 3-10D

Similarly to the Combitube®, the PtL® airway can be placed in either the esophagus or the trachea, placement confirmed, and a tube then chosen that will direct ventilations into the trachea.

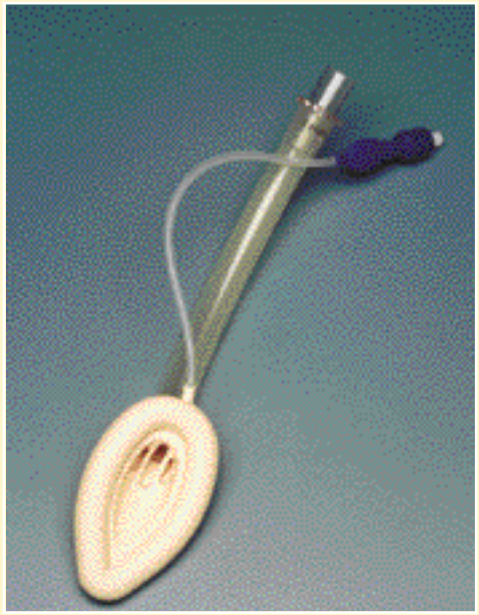

FIGURE 3-10E

The laryngeal mask airway (LMA). NOTE: Unlike the Combitube® and the PtL®, the LMA has no age restrictions. It may be used in children.

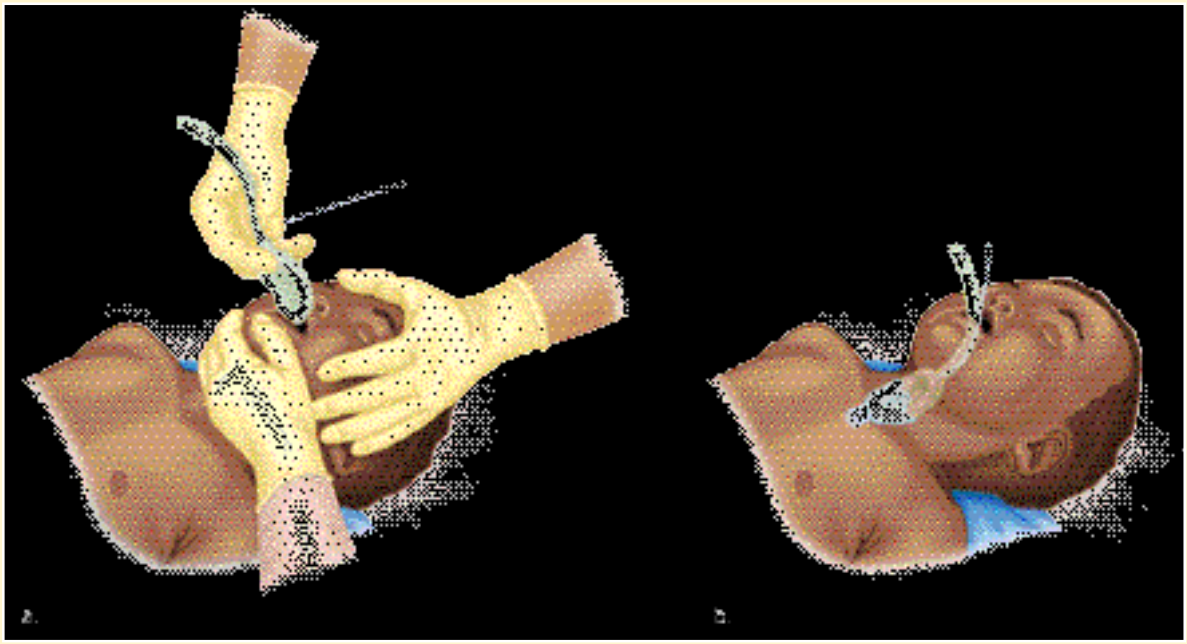

FIGURE 3-10F

The LMA consists of a ventilation tube attached to a cuff that can be inserted into the hypopharynx and inflated to seal off and protect the laryngeal opening. An advantage of the LMA is ease of insertion; a disadvantage is that it does not isolate the trachea. Thus it offers protection only from secretions or other materials in the pharynx but does not protect the trachea from material regurgitated from the stomach.

Summary

Oxygenation and ventilation are essential to pediatric care. In order to provide effective oxygenation and ventilation, a secure airway must be attained and maintained. In most cases, this goal can be accomplished with basic life support measures including positioning, suctioning, the use of adjuncts, and clearance of foreign bodies. If these methods fail to maintain an adequate airway, advanced life support maneuvers may be necessary. This may include endotracheal intubation, and in some cases this will be pharmacologically assisted.

Complete familiarity with the properties of relevant pharmacological agents is absolutely critical. Before using these agents, you must demonstrate a high degree of skill in direct laryngoscopy and intubation techniques and be expert at providing assisted ventilation in case intubation is unsuccessful. In addition, in rare cases where the airway cannot be obtained with basic life support maneuvers and attempt at intubation, percutaneous needle cricothyrotomy may be performed if resources and permission from medical direction are available.

Case Study Resolution

The tongue is the most common airway obstruction in pediatric patients. In the unconscious child or child with an altered mental status, it often falls to the back of the airway occluding the airway. With repositioning of the airway, the snoring improves. The unconscious child, José, begins to breathe, but on assessment you note that the rate is only four breaths per minute and shallow. Since his breathing is inadequate, you continue to maintain the airway while beginning assisted ventilations. Your partner completes the initial assessment, confirming that José is unresponsive to any stimuli, but that perfusion and heart rate are normal. He exposes the child as needed for further assessment.

Despite assisted ventilations with a BVM, you note that chest rise is still inadequate and you instruct your partner to intubate to secure a better airway. He sets up all the necessary equipment while you hyperventilate the patient. Your partner then successfully intubates José and confirms placement based on chest rise, bilateral equal breath sounds, and with the aid of a disposable end-tidal carbon dioxide detector. After intubation you note that there is good chest rise with assisted ventilations. Because José's condition is unstable, you immediately package and transport him. En route you assist ventilations and continually reassess tube placement and José arrives at the hospital unconscious but with improved respiratory effort.

References

APLS. Chapter 2, Advanced Airway Management: Rapid Sequence Induction for Emergent Intubation. AAP/ACEP (1998): 17–26.

Gausche, M., R. J. Lewis, S. J. Stratton, et al., "Effect of Out-of-Hospital Pediatric Endotracheal Intubation on Survival and Neurological Outcome: A Controlled Clinical Trial." JAMA 283(6) (February 9, 2000): 783–790.

Gausche, M., R. J. Lewis, S. J. Stratton, B. Haynes, C. R. Gunter, S. M. Goodrich, P. D. Poore, M. D. McCollough, D. P. Henderson, F. R. Pratt, J. S. S. Seidel. "A Prospective Randomized Study of the Effect of Prehospital Pediatric Intubation on Patient Outcome." Acad Emerg Med 5.5 (1998): 428.

Gausche, M., ed. Advanced Pediatric Life Support: The Pediatric Emergency Medicine Course Instructor Manual. 3d ed. Elk Grove Village, IL: American Academy of Pediatrics and Dallas, American College of Emergency Physicians, 1998. See "Airway Management Skill Station," 173–190.

Gerardi, M. J., J. B. Lungo, A. Scalzo, et al. "Emergency Intubation of the Pediatric Medical Patient: Use of Anesthetic Agents in the Emergency Department." Ann Emerg Med 28 (1996): 55–74.